VARIATION IN THE DIGESTION OF ENERGY BY BROILER CHICKENS

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Abstract

Feed is the largest single cost factor (60%) in production of chicken meat with cost of energy being a major consideration given that birds eat to satisfy an energy requirement. The Australian chicken meat industry is highly dependent on supply of energy from cereals such as wheat and barley that are known to vary widely in apparent metabolisable energy (AME). In contrast, sorghum is a relatively consistent source of energy.

Diets for broiler chickens are comprised mainly of cereal grains, legumes and protein-rich meals of plant and animal origin. The diets are formulated to provide essential nutrients for maintenance and rapid growth of the flock as a whole. However, some dietary ingredients may also have chemical and physical properties that can be detrimental to the processes of ingestion, digestion, absorption, transport and utilisation of nutrients. Soluble non-starch polysaccharides (NSP) in cereal grains such as wheat and barley can depress digestion of energy by broiler chickens.

This thesis examined the general hypothesis that the effects of soluble NSP in cereal grains on gut structure and function, digesta transit time, and gut microflora differ substantially between individual chickens within a flock, thus contributing to variation in the digestion of energy by the flock as a whole. A major goal of the research was to determine what characteristics of the gastrointestinal tract of broiler chickens were the key determinants of digestion of energy. Twelve experiments were conducted during this study. Breath tests involving measurements of carbon dioxide, hydrogen and methane were developed as non-invasive indicators of digestive function, and were used in conjunction with conventional methods for measuring energy digestion in commercial strains of chickens.

Sex of the chicken had a significant effect ($P<0.05$) on AME values obtained for a diet based on wheat with a high soluble NSP content. Females were superior to males (14.6 vs 14.0 MJ/kg DM), but strain of chicken had no effect on AME. Villus height and crypt depth in the intestinal epithelium were measured to determine if any relationships between gut morphology and AME could explain why males and females differed. Males had significantly greater ileal villus height than females ($P<0.05$). In one of the two strains of chickens studied, villus heights in the duodenum and jejunum tended to be greater in males than females ($0.05<P<0.10$). In the second strain of chicken, villus heights in the duodenum and ileum were lower ($P<0.05$) than those in the first strain, with little

differences observed between males and females. Crypt depth was unaffected by strain or by sex of the chickens. Thus, individual measurements of gut morphology were poor indicators of AME. Furthermore, only 33% of the total variation in apparent metabolisable energy (AME) could be accounted for by combinations of measurements of villus height and crypt depth in the duodenal, jejunal and ileal sections of the small intestine. It was concluded that other determinants of digestive capacity were collectively more important than gut morphology.

Energy excretion by male chickens was observed to rise in an exponential manner relative to energy intake, whereas the increase in females was linear. It was reasoned that increased energy excretion by males could be due to increased endogenous energy losses from the distal part of the intestinal tract, reduced production of volatile fatty acids (VFA) by microbial fermentation in the caeca, or reduced absorption of VFA by caeca. These possibilities pointed to the need for a closer examination of the role of gut microbiota on the digestive function of chickens. It was also clear that further studies should differentiate between digestion of energy in the small intestine (by measurement of ileal digestible energy) and whole of tract digestion (by measurement of AME).

Ileal digestible energy (DE) values for wheat and barley were unaffected by sex of chickens, whereas AME values were lower in male chickens compared with females. These results suggested that the sex-specific effects of microbiota occurred mainly in the hindgut. Furthermore, the influence of the gut microbiota on between-bird variation in AME was partially dependent on the type of cereal grain used in the diet, as indicated by the observation that the differential between males and females in expiration of hydrogen and methane in the breath changed according to the type of grain consumed. That is, the metabolic activity of the gut microbiota was influenced both by the sex of the chicken and by the properties of the diet.

The results of these studies provided evidence that microbial colonisation of the gut is a key determinant of the digestive function of chickens. Further work is needed to determine why microbial colonisation of the gut is variable and why it differs substantially between male and female chickens. Then it may be possible to control the initial colonisation of newly hatched chicks and to maintain a health-promoting profile throughout the life of chickens in order to enhance efficient production, and product quality and safety.